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The Wax Moth and Its Control

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ECONOMIC IMPORTANCE

The wax moth (*Galleria mellonella* (L.))[1] is responsible for large losses to beekeepers in the United States. It is found almost everywhere that bees are raised, but it does the greatest damage in the Southern States because of the long season of activity.

Probably the most noticeable injury due to the wax moth is to combs in storage, especially if they are in a warm, protected place. Such injury consists in destruction of the combs by the larvae, which leave them a mass of webs and debris (fig. 1). This type of damage is more common than the destruction of entire colonies. Weak, diseased, starved, or otherwise abnormal colonies are a prey of the wax moth, and in these colonies the combs are often entirely destroyed. In such cases, however, wax moth injury is secondary; strong colonies will defend themselves well against attack.

The larvae of the wax moth also do considerable damage to comb honey. The eggs are probably laid on the comb or section boxes before the comb-honey supers are removed from the hives, but the damage does not become evident until some time after the honey has been placed in storage. The damage consists of small, rather inconspicuous tunnels and borings through the thin wax caps of the honey cells. The honey leaks out through these holes, making the affected section unmarketable.

[1] This insect is also known variously as the bee moth, the bee miller, the wax miller, the wax worm, and the webworm.

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LIFE HISTORY

The Egg

The egg of the wax moth is small, white, and rather inconspicuous (fig. 2). It measures about one fifty-fourth of an inch in length and one-sixtieth of an inch in greatest width.

The eggs are probably laid most frequently in the cracks between hive parts—that is, between supers, between hive body and bottom board, or between super and cover. Egg masses have been found in

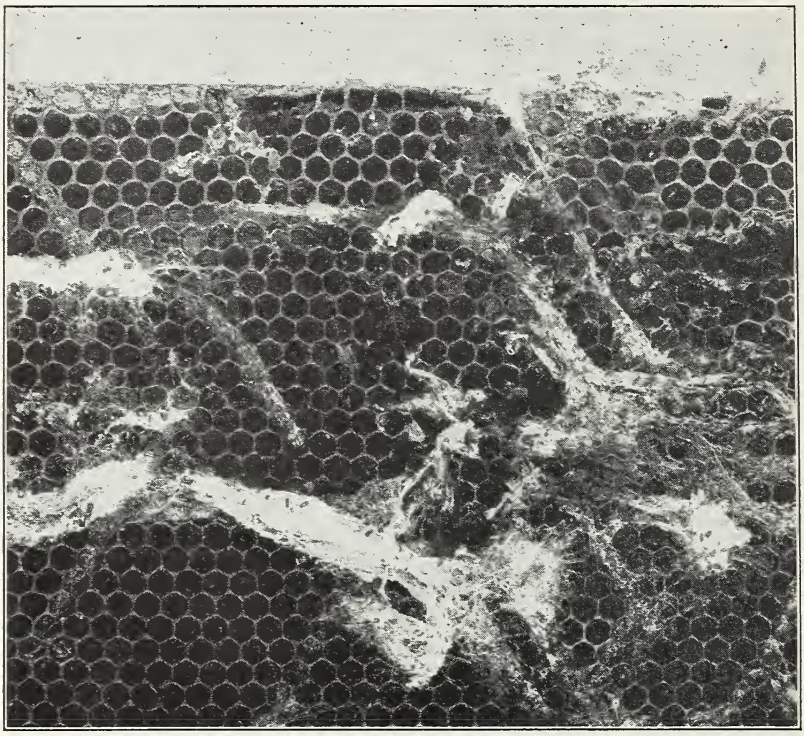

FIGURE 1.—Webs and tunnels made by larvae of the wax moth in a comb.

cracks between the inner cover and the top super of the hive, where they had apparently been deposited by females from outside the hive. Eggs are also laid inside the hive, almost always in places farthest from the light. They are difficult to see and may often be overlooked.

At 75° to 80° F. the eggs hatch in from 5 to 8 days, but at lower temperatures (50° to 60°) the incubation period may extend to 35 days.

The Larva

The young larvae are often seen on the inner covers of hives and in the cracks between supers and hive parts. They attempt to

burrow into the wax almost immediately after hatching. The first burrows are often incomplete and may be mere roughenings of the surface of the wax. After the first day, however, they make small tunnels between the cells and toward the midrib of the comb.

The growth of the larvae depends chiefly on the quantity and quality of their food and on the temperature. The length of the larval period ranges from 28 days to 4 months and sometimes to nearly 5 months. During this period the larvae grow from about one twenty-fifth of an inch to seven-eighths of an inch in length.

The food of the larvae consists in part of impurities in the wax, and in obtaining this food the larvae ingest the wax itself. Foundation, especially in frames, is seldom attacked, and then usually only by the small larvae. Although larvae can develop on foundation,

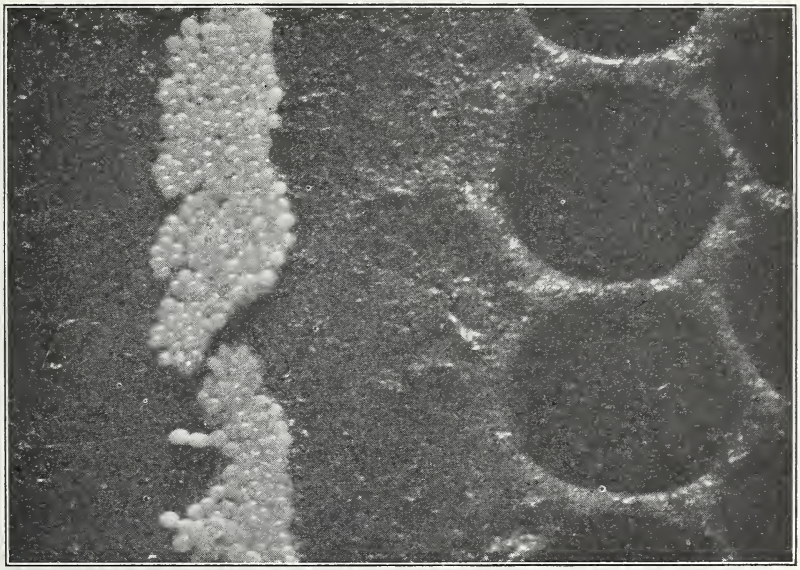

FIGURE 2.—Eggs of the wax moth laid on a comb. Greatly enlarged.

the mortality of such larvae is high, and the developmental period of those that survive is relatively long. It is almost certain that some of the damage reported by beekeepers as caused by the lesser wax moth (*Achroia grisella* (F.)) is the work of such poorly fed larvae of *Galleria mellonella.*

The optimum temperature for the development of the larvae is between 85° and 95° F., about that normally found in a beehive during the active season. At 40° to 45° the larvae seem to become dormant, and no feeding or growth takes place.

THE PREPUPA

When full-grown the larva spins a dense, tough, silken cocoon Usually this cocoon is firmly attached to the side of the hive, the frame, or other solid support, but some cocoons are found in the mass

of tunnels and refuse of the wax on the frames or on the bottom of the hive (fig. 3). Frequently the cocoon is placed in a hollow chewed out of the wood of the hive or frame. Frames may be found in which holes have been chewed completely through the end or top bars, with the cocoon and pupal case inside these holes.

The Pupa

Within the cocoon the larva changes to the pupa. The duration of the pupal stage within the cocoon ranges from 8 to 62 days, depending on the temperature. As with many other insects, the pupal period allows the wax worm to pass through the fall and winter protected against climatic influence. In the South, especially in warm winters, the adults may emerge at any time.

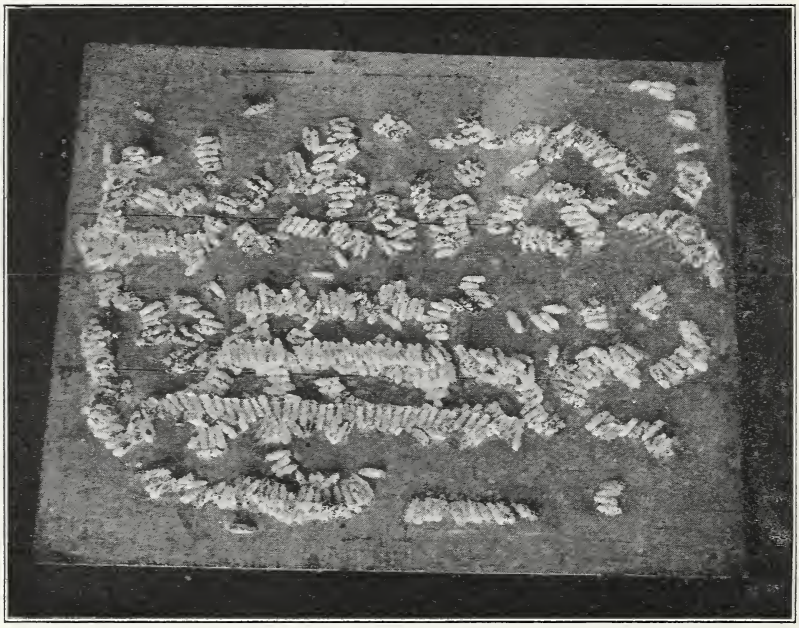

Figure 3.—Pupal cases, or cocoons, of the wax moth.

The Adult

The normal adult wax moth is about ¾ inch in length and has a wing spread of about 1 to 1¼ inches (fig. 4.) Adults are commonly seen in the resting position with their grayish-brown wings folded in rooflike fashion (*A* and *B*). The moths are not easily disturbed, but when molested they run rapidly before they take wing. The males are slightly smaller than the females and may be distinguished from them by the shape of the outer margin of the fore wing, which is notched in the male but smooth in the female, and by the absence of palpi, which are prominent in the female.

The moths vary widely in size and color, according to the type of food consumed by the larvae and to the length of the developmental

period. Small, poorly nourished larvae, or those which, because of low temperatures or other factors, develop slowly, transform into small adults, sometimes less than half the normal size. Larvae fed on dark brood combs transform into adults which may be dark gray to almost black, while larvae reared on foundation become silvery-white moths, which are smaller than those reared on brood comb.

The female starts depositing eggs from 4 to 10 days after emergence and continues depositing them as long as her vitality lasts. Egg laying may be rapid at times, and as many as 102 eggs have been deposited by a female in 1 minute. The total number of eggs laid by a female varies considerably, but it is usually less than 300. The adults may live as long as 3 weeks.

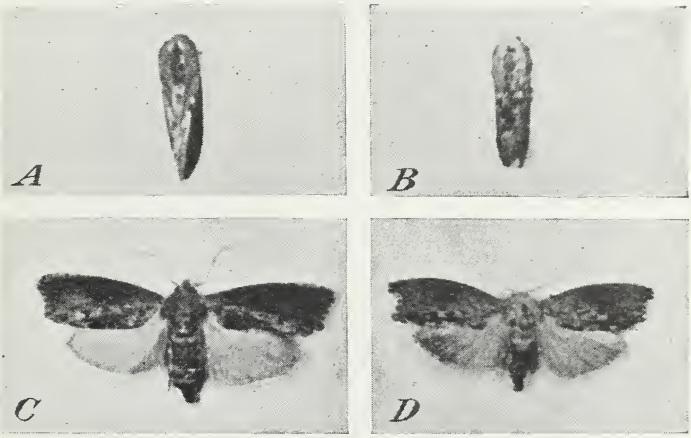

FIGURE 4.—Adults of the wax moth: *A* and *B*, With wings folded; *C* and *D*, with wings spread; *A* and *C*, females; *B* and *D*, males. Note the deep clefts in the tips of the fore wings of the male.

NUMBER OF BROODS

It seems doubtful that there are definite generations of the wax moth during different periods of the year in the Southern States. Rather it is probable that the moth is always present, that larvae in all stages, pupae, and adults may be found at any time, and that development is continuous except during periods of low temperature.

OTHER MOTHS CAUSING DAMAGE TO STORED COMBS

The lesser wax moth (*Achroia grisella*) also does some damage to stored combs. Its work is similar to that of the wax moth, but the tunnels are smaller, the webs finer, and feeding and webbing are more confined to the outer surface of the combs. The Mediterranean flour moth (*Ephestia kuehniella* Zell.) is a pollen feeder but does some damage to combs by boring tunnels through the midrib. This moth also tunnels into brood cells and consumes the food intended for the developing bee larvae. These two moths may be controlled by the methods given for the wax moth.

CONTROL

Control Measures in the Apiary

Beekeeping practices and manipulations should be based on the assumption that the wax moth in some stage may be present in the hives at all times. The bees are the most effective natural enemies of wax moths. The bees will, when the colony is strong, carry the moths out of the hive, and there is no better insurance against the ravages of the pest than to have strong queenright colonies. Accidental loss of queens in colonies late in the fall may mean the loss of colonies from wax moth damage before the first spring examination.

In addition to strong colonies the best control measure is cleanliness of hives—removal of propolis, bur combs, and refuse on the bottom board, which provide protection for larvae of the wax moth, even in strong colonies.

From the standpoint of both productive beekeeping and wax moth control, box hives or hives in which the frames are not easily movable should be replaced by modern equipment. Such hives give the wax moth an opportunity to reproduce, and they provide breeding places from which other colonies may be attacked.

Control of the wax moth by trapping the adults at lights or by means of trap combs has not been successful.

Control Measures for Stored Combs

Since light and air repel both the adult moths and the larvae, stored combs will be less subject to destruction if they are exposed to the light by setting the supers on end and spaced to allow ventilation. The common method of storing combs in tightly closed, crowded hive bodies is highly favorable to wax moth infestation and development.

The use of chemicals to kill the wax moth has proved the most satisfactory measure thus far for controlling this insect in stored combs. Several fumigants have found favor for this purpose, particularly paradichlorobenzene, carbon disulfide, and calcium cyanide. Other fumigants that have been used include fumes from burning sulfur, carbon tetrachloride, and methyl bromide. These materials have been found to kill all stages but the egg, and methyl bromide is even effective against the eggs of the wax moth. Some of these fumigants, however, have definite limitations; on others not enough research work has been done with the wax moth to justify recommendation of their use to beekeepers.

PARADICHLOROBENZENE

Paradichlorobenezene ("PDB") is a white crystalline substance which evaporates slowly in air. The gas is not unpleasant to smell and when used as directed will not be found injurious to people. Higher concentrations, however, are irritating, and the crystals must be handled in such a manner as to prevent their being taken internally by accident. It is heavier than air, noninflammable, and nonexplosive.

In paradichlorobenezene fumigation the supers should be stacked as tightly as possible and the cracks between them covered with

strips of gummed paper (fig. 5). Three ounces of the crystals to a stack of five 10-frame hive bodies may be sprinkled directly on the top bars of the frames, as in figure 5, or preferably put on a piece of paper or cardboard laid on the top bars. The cover should then be put tightly in place. Since the gas is nonpoisonous and not disagreeable, treatment may be made in ordinary storage, it being unnecessary to take the infected material out of doors. At intervals during the storage season the covers of the stacks should be raised, and if no crystals are still present more should be added.

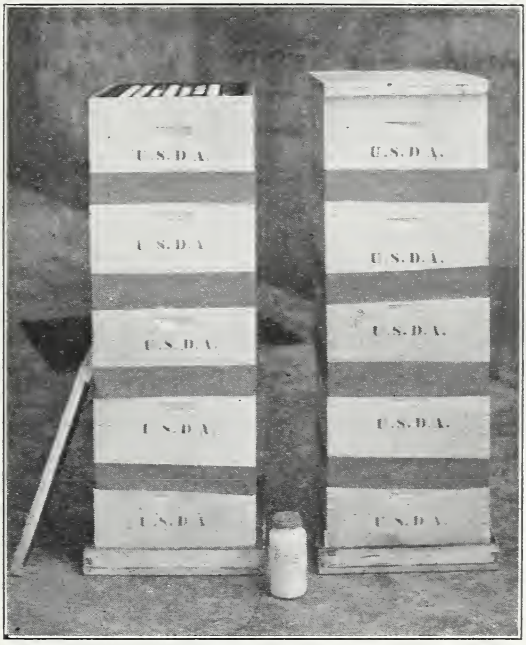

FIGURE 5.—Supers loaded with comb ready for fumigation. The joints are sealed with gummed paper tape, and the crystals of paradichlorobenzene have been sprinkled heavily over the top bars.

Paradichlorobenzene is most effective at temperatures above 70° F. and volatilizes more rapidly as the temperature rises. Stored materials should be inspected at intervals of 2 or 3 weeks, depending on the temperature of the storehouse and the prevalence of moths.

CARBON DISULFIDE

Carbon disulfide has been a standard fumigant for wax moths and similar insects until recently, and with proper precautions it is still considered satisfactory. The commercal product is a yellowish, somewhat oily liquid, which changes readily at ordinary temperatures into an ill-smelling gas. The liquid is about one-fourth heavier than water, and the gas is heavier than air. **It is highly inflammable, and the vapor is explosive when mixed with air in certain proportions; therefore, this chemical must not be handled around fire of any kind. At certain concentrations it can be ignited by**

hot steam pipes. Preferably it should be used out of doors or in a well-ventilated or open shed.

For carbon disulfide fumigation the supers should be sealed in the same manner as for paradichlorobenzene. One ounce of liquid is sufficient for five supers, and more than this number of supers should not be placed in a single stack, because the gas, being heavy, quickly sinks to the bottom of the stack and may not adequately fumigate the top super. The stack should remain sealed for not less than 12 hours. Since carbon disulfide is not effective against the eggs of the wax moth, it may be necessary to repeat the treatment after any eggs have had time to hatch.

CALCIUM CYANIDE

Calcium cyanide is obtainable either as a dust or as fine or coarse crystals. For use in fumigating bee equipment the crystals, containing not less than 40 percent of calcium cyanide, are preferable to the dust. In the presence of moisture, such as that in the air, the crystals release a deadly gas, which is noninflammable and nonexplosive as ordinarily used in fumigation. **It is, however, extremely poisonous to people and animals, and care must be taken not to breathe the gas, the pronounced odor of which is discernible when the container is opened. The fumigation should be conducted out of doors, and it is safer to wear a suitable gas mask when handling calcium cyanide in any form.** For use, put 1 tablespoonful of crystals on a sheet of paper and place the paper on top of the frames in a super. Quickly place the other supers on top, using not more than five supers per stack, and tape the joints between supers with gummed paper tape. The stacks of supers should not be disturbed for 24 hours after fumigation, and the combs should be well aired before they are used.

Fumigating and Storing Comb-Section Honey and Honey in Extracting Frames

The control of wax moth damage in honey stored in comb sections or in frames is the same as for other stored combs. Honey, however, absorbs odors readily, and the odor of paradichlorobenzene is absorbed and held easily, being especially objectionable in mild-flavored honeys. The gas given off when calcium cyanide comes in contact with the moisture in the air is not absorbed by honey. Calcium cyanide dust should not, of course, be applied directly to honey in the comb, but should be placed on a cardboard or in a container of some sort. Stored honey should not be exposed to any fumigant for long periods.

Much of the honey produced for market in comb sections is mild in flavor, and the absorption of even slight amounts of a foreign odor is objectionable. Carbon disulfide is the most satisfactory fumigant for comb honey. As soon as sections are well sealed, they should be removed from the hives, placed in supers, and stacked not more than 8 to 10 high. The directions given previously for fumigating combs can be followed, with due care for the inflammable and explosive nature of this fumigant.

After fumigation the comb-honey sections should be stored in a moth-free room that is clean, well lighted, and ventilated to discourage the wax moths, which prefer to lay their eggs on beekeeping equipment in dark, poorly ventilated places.

Honey is best protected by extracting it as soon as possible after removing it from the hives, since in tin or glass containers it is safe from attack by wax moths, mice, ants, or other pests, as well as from contamination by fumigants or other odors. Beekeepers sometimes wish to store full frames of honey, or extracting may have to be delayed. In either event if there is danger of infestation by wax moths, the honey should be fumigated as indicated for comb-section honey.

Paradichlorobenzene may be used for fumigating frames of honey that are to be fed back to the bees, for bees do not object to a slight odor of this chemical, but this fumigant should not be used to protect frames of honey that are to be stored for long periods and then extracted with the intention of marketing the honey, as the odor is definitely objectionable to consumers.

General Directions for Fumigation With Paradichlorobenzene, Carbon Disulfide, and Calcium Cyanide

(1) Use not more than five supers in a stack and seal the joints with gummed paper tape to make the stack as nearly gastight as possible. With gases heavier than air, make sure that the base of the stack is tightly closed, since the gases sink to the bottom of the stack and may escape. A pad of newspapers placed beneath the stack will help to confine the gas.

(2) If calcium cyanide is used, fumigate out of doors. The same applies to carbon disulfide if there is the least danger of fire; at all events apply the latter in a well-ventilated room. Read carefully the directions for using the selected fumigant and have everything ready before beginning the fumigation.

CAUTION.—Carbon disulfide gas is highly explosive, and any chance of ignition must be carefully guarded against. Carbon disulfide and calcium cyanide and their gases are poisonous to people and to animals, and must therefore be stored and handled with extreme care.

(3) To fumigate with paradichlorobenzene, put the crystals on a piece of paper and lay it on the top bars of the top super; renew them as needed.

(4) Since paradichlorobenzene, carbon disulfide, and calcium cyanide are not effective against eggs of the wax moth, subsequent fumigations may be needed. If the temperature following the first fumigation is about 70° F., it is well to repeat the treatment after about 2 weeks. The fumigated stacks should be left sealed for about 24 hours.

(5) Following fumigation, air the combs thoroughly before using them in the apiary.

Table 1 gives an outline for reference in fumigating stored combs and honey against the wax moth.

TABLE 1.—*Summarized information on fumigating stored combs and honey against the wax moth, based on a stack of 5 standard 10-frame supers*

Fumigant	Characteristics of the gas	Quantity to be used	Length of treatment	Remarks
Paradichlorobenzene	Nonpoisonous to humans, noninflammable, nonexplosive.	3 ounces or 6 tablespoonfuls.	Keep supply in stack throughout storage period.	Inspect supers at 2- or 3-week intervals.
Carbon disulfide	Poisonous to humans, highly inflammable, highly explosive.	1 ounce or 2 tablespoonfuls.	Not less than 24 hours	Repeat once after 2 or 3 weeks.
Calcium cyanide	Extremely poisonous to humans, ordinarily noninflammable and nonexplosive.	½ ounce or 1 tablespoonful.	do	Do.

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